PhD. SYNOPSIS

Digital Technology Assisted Nutrition Support for Children with Attention Deficit Hyperactivity Disorder

Submitted by

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INTRODUCTION

Attention Deficit Hyperactivity Disorder, known as ADHD, is among the most common behavioural disorders of children worldwide, with an estimated prevalence of 5.3%. ADHD is generally classified into three subtypes: Predominantly hyperactive, predominantly inattentive, and combined. After undergoing numerous revisions in the criteria required for the diagnosis of ADHD, The American Psychiatric Association's Diagnostic and Statistical Manual, Fifth Edition (DSM - V) is used as the diagnostic tool or the ICD-10 (International Statistical Classification of Diseases), published by the WHO in 2013 is used for diagnosis. In ICD-10, ADHD is classified as a hyperkinetic disorder and requires meeting the criteria for both hyperactivity and inattention. The possibility of both existing in a child is less prevalent than the existence of either hyperactivity or inactivity. Thus, the prevalence rate of ADHD according to the ICD-10 classification is less.

Several studies in the United States have discovered that the prevalence of ADHD has increased in recent years. According to an examination of the National Health Interview Survey (NHIS), the prevalence of ADHD among children and adolescents aged 3 to 17 years increased from 5.7 per cent in 1997-1999 to 33 per cent in 2006-2008. (7.6 per cent). The National Survey of Children's Health found a 42% increase in the frequency of diagnosed ADHD among children and adolescents aged 4 to 17 years between 2003 and 2011.In India, the prevalence is at 11.32 per cent (Venkata & Panicker, 2013). The incidence of ADHD among boys has been more than among girls and the prevalence varies according to the type of ADHD, too (Mukhopadhyay, S. Misra, Misra, & Niyogi, 2003). It has also been observed that ADHD of the hyperactive type is more prevalent among boys.

Comorbid disorders are common among children with ADHD. In one large epidemiological study, 44% of children with ADHD had one or other psychiatric

disorder, 32% had at least two different conditions, and 11% had at least three other disorders. Children with ADHD have academic difficulties. Their behavioral symptoms of inattention, hyperactivity and impulsivity indicate lack of concentration in children with ADHD, due to which they have problems in academic domains. Children with ADHD often show difficulties in academics, with particular problems in reading and math. Compared with conduct disorder, several studies find ADHD to be more strongly associated with reading disorders than with mathematics disorders.

The etiology of ADHD is multifactorial, and both genetic and environmental factors may be involved in ADHD. Family and twin studies have shown that genes play an important role in the development of ADHD. Genome-wide association studies are inconclusive, but candidate gene studies suggest the involvement of genes related to the receptors and transporters of dopamine and serotonin. Proposed ADHD environmental risk factors include heavy metal and chemical exposures such as lead, mercury, organochlorine, organophosphates, and phthalates, as well as nutritional and lifestyle/psychosocial factors.

The effect of diet and dietary supplements is considerable evidence suggests that dietary factors are associated with childhood behavioral disorders such as ADHD. Low levels of copper, iron, zinc, magnesium, and omega-3 fatty acids have been reported in children with ADHD, and sugar, artificial food colourings, and preservatives are associated with an increased risk of ADHD. Recently, the association between dietary pattern and ADHD has been examined in several studies. As nutrients are consumed in combination and because nutrients are highly interrelated, the study of dietary patterns is useful to further understand the overall role of diet in ADHD.

The proposed tool can be developed as a mobile app for Mobile devices or a web based application for computers/ handheld devices. Chatbot and FAQ’s for quick appraisals can be made available in the application. It helps the user to access information and communication (BMI calculator, calorie counter, personalized and general diet tips) from anywhere in the world. The proposed solution uses technology to take the service of Dietitians to its targeted users. Evidence based, personalized nutrition web pages can be offered in authentic manner by creating the website and incorporating AI into it.

Internet and smartphone use has grown exponentially in the past decade, opening up the possibility that these increasingly prevalent technological tools could improve health. Digital health interventions (DHIs), including such modalities as telemedicine, Web-based strategies, e-mail, mobile phones, mobile applications, text messaging, and monitoring sensors, are the most recent emphasis of an effort to shift health care burden outside the walls of medical institutions and improve individualized care through positive behavior change theory. Educating Caregivers on the importance of diet and the possible implications of a compromised diet pattern, on the physical and the mental development of children needs to be emphasized by taking advantage of all the communication media.

Hence, the present study is centered to evaluate the etiology, nutritional intake, physical activity pattern and its effect on clinical symptoms of children with ADHD symptoms and to provide sustainable intervention to maintain cognitive and behaviour functions through digital health intervention in web applications and one to one telephonic counselling with nutrition education and to evaluate the effectiveness of intervention.

CHAPTER SCHEME

CHAPTER 1 – INTRODUCTION

Introduction to ADHD, Types of ADHD, Causes of ADHD, Prevalence of ADHD, physical pattern of ADHD, clinical symptoms of ADHD,Knowledge about ADHD symptoms, intervention study comparing effectiveness of diet modification and digital health intervention and one to one telephonic counselling with nutrition education, rationale of the study and objectives are discussed in this chapter.

Objectives of the present study

Primary objective

- Provide nutrition support for Children with ADHD symptoms during Covid- 19 pandemic.

Secondary objectives

- Study the health and nutritional status of children with ADHD symptoms.
- Formulate micronutrient rich snacks.
- Apply digital technology for health and nutrition intervention
- Evaluate the impact of digital health intervention and dietary modification in reducing the symptomatology of ADHD.

CHAPTER II -REVIEW OF LITERATURE

This chapter comprises literature on children with ADHD symptoms – health and Nutritional status of children, elimination diet, Micronutrient deficiency among children with ADHD symptoms and Digital health intervention.

CHAPTER III – METHODOLOGY

The methodology of the study is presented as follows:

I. SELECTION OF AREA AND SUBJECTS

The area selected for the study was Chennai city in Tamil Nādu to evaluate the impact of the intervention on children with ADHD symptoms (4-12 years). Not many studies have been carried out on children with ADHD symptoms in this area. The purposive sampling method was used to select 10% out of 23 special schools in Chennai City, representing four zones (North, South, East, West). A judgmental sampling method was adopted to select some specific characteristics which are required for the study. It is the least expensive, most accessible, and doesn't need a rundown of the sample population. Every caregiver provided informed consent before participating in the study. Children who were selected for the study had a precise diagnosis of ADHD symptoms from qualified psychiatrists. The selection of this age group is to provide more insight into children with ADHD symptoms associated with Micronutrient deficiency and to prevent ADHD symptoms related to comorbid disorders in future through digital health and dietary intervention.

II. Conduct of Survey (Interview Schedule & Google forms - Caregivers):

One hundred thirty-seven subjects were included in the study through purposive sampling. The inclusion criteria for the subjects were Children with ADHD symptoms between 4-12 years of age, and the exclusion criteria were Children severely affected with physical disabilities, severe autism and mental retardation, age groups less than 4 and more than 12 years. As part of the data collection process, written consent from the subjects was obtained, and ethical clearance was obtained by the Institutional Human Ethics (certificate no.: AUW/IHEC/FSN-20-21/XPD-27.). A structured, well-designed interview schedule was used to collect background data on socioeconomic status, health status, parent health status, dietary pattern, and physical activity pattern of caregivers. Data collection was conducted through face-to-face interviews before the pandemic and through a Google form during the pandemic.

III. ASSESSMENT OF NUTRITIONAL STATUS AND BEHAVIOUR FUNCTIONS:

In this phase, the nutritional status of children with ADHD symptoms was assessed with reference to standards using Anthropometric measurements such as height and weight were measured according to the NCHS procedure from which BMI (Body mass index) was calculated. Clinical examination is the simplest and most practical assessment tool used to assess nutritional status. Based on the WHO evaluation protocol, the hair, skin, eyes, mouth, teeth and tongue of all children were examined. The children's behaviour function was determined by the assessment of the clinical signs and symptoms of children with ADHD symptoms observed and documented with the help of DSM-5 criteria checklist. The dietary pattern assessment includes collecting information on food frequency consumption, 24 hours food recall survey, food preferences, inclusion and omission of foods, preference for junk foods and food customs and beliefs. From the food intake, the mean nutrient intake of the children was calculated and compared with the RDA suggested by ICMR (2020).

IV. FORMULATION AND STANDARDISATION OF SNACKS

The formulation of snacks is commonly consumed in recipes in South India with high nutrient content of Zinc, Omega-3 fatty acid, and Iron. In order to prepare snacks, cereals and millets, pulses, fruits, green leafy vegetables and other vegetables of the five food groups were used. Three variations of the functional ingredients mix will be used in the formulation of snacks to standardise the recipes. During sensory analysis, the panel members were instructed on the evaluation procedure, and score ratings were obtained. In three variations which obtained high acceptability scores were chosen for the nutrient analysis.

V. ANALYSIS OF PHYSICAL QUALITIES, NUTRIENT CONTENT, MICROBIAL COUNT

The physical characteristics like weight, width, diameter, thickness and spread factor were determined. The physical characteristics were measured according to the methods described by Mc Watters et al., (2003). The physical measurements were recorded for the standard and formulated snacks. The formulated snacks were used

for the analysis of the nutrient content. Analysis of different nutrients in prepared snacks was carried out using the standard methods suggested by the Association of Analytical Chemists International (AOAC) procedure. The microbial count of the formulated snacks was done in the microbiology lab. The result of the score was tabulated. The microbial count gave valuable information on the keeping quality of the cookies, which were prepared without using preservatives.

VI. DEVELOPMENT OF ARTIFICIAL INTELLIGENCE INTEGRATED WEBSITE

An AI-integrated dynamic website was designed with the assistance of a web design company. The website domain name was “nutritionadhd.com”. The purpose of this website is to provide support, especially for the special educators, caregivers and parents of children with ADHD symptoms. This web portal provides an overview of ADHD, chatbot, nutrition support, expert talks, nutrition games for children, and YouTube Videos with reference to the Indian Context. The portal was open to all, but caregivers provided feedback before and after using it. The feedback on the qualitative assessment done by the caregivers was converted into percentages and tabulated.

VII. IMPLEMENTATION OF INTERVENTION STRATEGIES

The number of 120 participants consisting of the experimental group (n= 60) and the control group (n= 60) were divided into different age groups (4-6 & 7-9 years) having children with ADHD symptoms were selected for the study by purposive sampling method. The written consent was collected from the selected participants of the experimental (n=60) and control groups (n=60). The impact of nutrition intervention (diet modification, digital health intervention and nutrition education) changes nutritional status, symptoms of ADHD, and knowledge of ADHD caregivers.

One hundred twenty children were divided into two age groups as follows:

- ✓ Experimental Group (4-6 years) (n=60) - Diet modification + Digital health intervention
- ✓ Control Group (4-6 years) (n=60) - One-to-one telephonic counselling and Nutrition Education

- ✓ Experimental Group (7-9 years) (n=60) - Diet modification + Digital health intervention
- ✓ Control Group (7-9 years) (n=60) - One-to-one telephonic counselling and Nutrition Education

VIII. EVALUATION OF THE IMPACT OF NUTRITION INTERVENTION

The selected children in EG and CG were monitored closely, and the impact of intervention strategies was evaluated before and after intervention for five months. Anthropometric measurements were recorded using standard procedures, and the nutritional status of the children was assessed with the help of the NCHS growth chart. The clinical assessment of the children was elicited using the DSM- 5 criteria scale**.** Pre and Post-test questionnaires on Knowledge, Attitude and Practice were administered to the mother before and after conducting the nutrition education, which included awareness on overview of ADHD, physical activity, intake of Zinc, Iron and omega-3 fatty acid-rich foods. Changes in post-dietary modification were assessed using a three-day recall method and compared with dietary intake before intervention.

IX. STATISTICAL ANALYSIS OF THE DATA

The data collected was recorded, tabulated, consolidated and analyzed using appropriate statistical methods.

CHAPTER IV - RESULTS AND DISCUSSION

The age group between 4-12 years were included for the study. Among the selected children with ADHD symptoms 29.2 percent belonged to 4-6 years, 59.9 percent were 7-9 years, and 10.9 percent were 10 to 12 years.

It was observed that 66.4 percent of the children with ADHD symptoms were boys and 33.6 percent were girls.With regard to the family size about 66.4 percent of the children belonged to nuclear families and 33.6 percent were from joint families. Ordinal position wise, about half of the children i.e., 70 percent were first born children.

The family income of the selected children was 10.9 percent for low income, 54 percent belonged to middle income and 35 percent were from a high income family (HUDCO,2007). 64.2 percent were Hindus, 24.8 percent were Muslims, and 15 percent were Christians.

The data pointed to blood relationship marriage at 67.15 percent of the mothers. These mothers were below 20 years of age when they got pregnant. While reviewing the personality traits of parents, fathers had an aggressive personality about 58 percent.

56.9 percent of the children with ADHD symptoms were in the combined subtype as per the DSM V criteria. Hyperactive behaviour was observed among 23.3 percent of the children. Only 12.4 percent of the children with ADHD symptoms were termed as inattention behaviour in the present study.

With respect to the blood group of the children the data indicated that about 37.95 percent were found to be AB+ followed by 32.84 percent of O+.

The mean height and weight were below the standard in children of all three age groups, while BMI was below standard in children with ADHD symptoms between 4 to 6 years (14.7) and 7 to 9 years (19.8) and 10 to 12 years (34.2). About 43.07 percent of the children were found to be underweight, 23.36 percent of children were found to be overweight and 25.56 percent of them were of healthy weight according to the CDC growth chart.

The details on dietary intake revealed that the number of children 59.9 percent were non-vegetarians and 34.3 percent of them were vegetarians. It was observed that over one third (81.0%) of the children skipped their meals, especially breakfast.

From the total response, 31.3 percent and 22.6 percent spend their time in indoor and outdoor activities. Mainly activities like watching TV 13.1 percent, web surfing 11.7 percent, dancing 5.1 percent, music 3.4 percent, and focus therapy 8.0 percent.

The mean food intake includes cereals, pulses, green leafy vegetables, other vegetables, fruits, and milk and milk products was lower than ICMR recommendations among the children with ADHD symptoms of all the three age groups. Fats and oil intake was mildly high. Energy, protein, carbohydrates, fats, calcium, magnesium, iron, zinc, vitamin B6 and B12, vitamin A, C and D. Intake was below RDA in all three age groups.

It is evident that formulated snacks can be used to prepare commonly consumed recipes such as cookies, cutlet, nuggets, smoothie, muffins, pakora, nutbar, seed-bar, and crackers. The sensory evaluation showed that the recipes like the third variation of the formulated snacks were best accepted with the highest mean score.

The formulated snack was analysed for its nutrient content following the procedures suggested by AOAC.The mean and standard deviation value obtained from the triplicate analysis of nutrients such as energy, protein, carbohydrates, crude fibre and dietary fibre, fats, calcium, magnesium, iron, zinc, vitamin B6 and B12, phosphorus, vitamin A and C showed high essential nutrients for the improvement of undernutrition and behaviour function.

Eighty percent of the mothers of children with ADHD symptoms were very satisfied with the design of the nutrition website in Indian ideology. Changes in mean score before and after the usage of the website showed significant ($p<0.01$) difference in the ADHD caregivers.

It was found that experimental group when compared to controlled group have the effect of dietary modification on food intake with significant ($p<0.01$) increase in consumption of cereals, fruits, milk and milk products and fats and oil between the age group of 4 to 6 and 7 to 9 years of age and pulses, green leafy vegetables, and other vegetables showed statistically significant ($p<0.05$) difference which was increased before and after intervention of the children.

Effect of dietary modification showed a significant increase in energy, carbohydrates, protein, fats intake in children with ADHD symptoms between 4 to 6 years whereas fats intake were not statistically significant between the age group of 7 to 9 years. In children between 4 to 9 years calcium, magnesium, iron, zinc, beta-carotene, vitamin B6 and B12 intake were increased significantly.

Statistical analysis revealed a significant difference ($p<0.01$) between the initial and final values indicating that changes in nutrition knowledge, attitude, practice given for a period of eight months improved the nutrition knowledge of ADHD caregivers.

CHAPTER V - SUMMARY AND CONCLUSION

- Background of children with ADHD symptoms between 4 to 12 years living in areas of Chennai city was studied.
- This study concluded that biological relation in marriage had a significant impact in causing ADHD symptoms among children.
- Subtypes of ADHD symptoms can be associated with male children, middle income family group, and nuclear family.
- Anthropometric assessment of the children were found to be affected by clinical and dietary patterns of the children with ADHD symptoms suffering from severe malnutrition and being overweight.
- Digital health intervention modules were developed and implemented on children with ADHD symptoms in two groups, experimental group (diet modification and digital technology),

controlled group (nutrition education) and impact was evaluated using aptitude test, and three-day recall method.

- ❖ Micronutrients such as zinc, iron, magnesium and Omega-3 fatty acids rich formulated snacks show significant reduction in symptomatology.
- ❖ During COVID-19, digital technology assisted nutrition support showed significant reduction in clinical symptoms of ADHD among children.
- ❖ Digital technology assisted diet modification for children with ADHD symptoms.

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